(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 497 066 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **91402591.1**

(22) Date of filing: **27.09.91**

(51) Int. Cl.5: **C23C 14/54**, H01J 37/32, C23C 14/56

(30) Priority: **30.01.91 JP 29431/91**

(43) Date of publication of application: **05.08.92 Bulletin 92/32**

(84) Designated Contracting States: **DE FR GB**

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# (54) A sputtering apparatus.

(57) The sputtering apparatus which can be inserted in a continous manufacturing line comprises judging means (51) for judging whether or not a normal thin film has been satisfactorily deposited on the surface of a substrate to be processed in a film deposition apparatus (3).

The apparatus comprises necessary condition-determining means for determining conditions necessary for depositing a normal thin film on the surface of the substrate to be processed, executed result-detecting means for detecting the results of a thin film deposition process, by sensing e.g. the pressure in a vacuum chamber or the waveform of discharge output power supplied from a discharge power source, comparing means for comparing the executed results detected by the executed result-detecting means with the necessary conditions determined by the necessary condition-determining means, and judging means (51) for judging immediately after the sputtering process whether or not the thin film-deposition process has been satisfactorily performed on the basis of the comparison results produced from the comparing means.

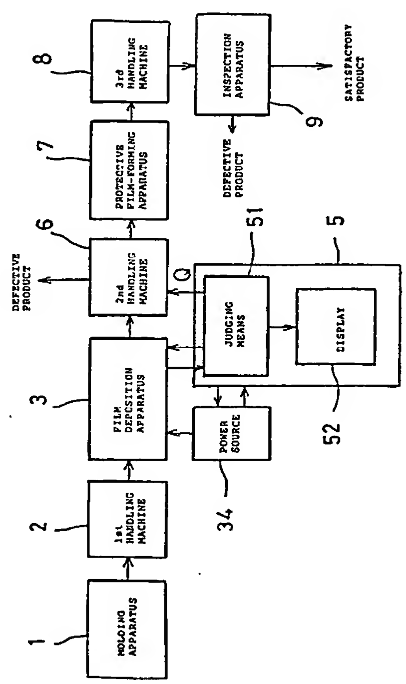


FIG. 1

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## BACKGROUND OF THE INVENTION

### Field of the Invention:

This invention relates to a sputtering apparatus, and more particularly to a sputtering apparatus that can judge whether or not a prescribed film deposition process has been satisfactorily performed on the basis of the detection results of the abnormalities in the sputtering process.

### Description of the Prior Art:

In recent years, a compact disk (hereinafter, referred to as a CD) and a laser disk have been widely used to record a large amount of digitized sound and image information. The substrate of the CD is made of transparent synthetic resin such as polycarbonate and the like. A large number of so-called pits are formed on the surface of the substrate in accordance with digital information of "1" or "0". Further, an aluminum thin film having a high light-reflectivity is deposited on the pits-formed surface of the substrate by use of a sputtering technique. The thus recorded information can be read by the presence or absence of the reflected light of a laser light beam applied to the CD. The aluminum thin film deposition per a single sheet of the substrates can be performed in a relatively short time. Thus, the continuous film deposition process with respect to a large number of substrates can be achieved.

A conventional sputtering apparatus generally has a configuration shown in Figure 12 and Figure 13. Specifically, digital information of "1" or "0" is recorded on the substrates by use of a press-molding technique, which is performed in a molding apparatus 1. The information-recorded substrate 4 is transferred by a first handling machine 2 into a film deposition apparatus 3, which has a configuration shown in Figure 13. In Figure 13, a light-reflecting film is deposited on the surface of the thus transferred substrate 4 in a film deposition chamber 31 (which is a vacuum chamber) by use of a sputtering source 32. The sputtering source 32 incorporates a target 33 disposed opposing to the substrate 4. In Figure 12, a DC power source 34, which supplies pulse-shaped sputtering power of about 15 KW at a maximum, is connected to the film deposition apparatus 3. Specifically, the sputtering power is applied across the target 33 and the substrate 4 so as to perform the sputtering process in the film deposition chamber 31, as shown in Figure 13. Further, a control unit 5 is connected both to the DC power source 34 and the film deposition chamber 3 so as to control a series of sputtering processes.

However, in the above-described conventional sputtering apparatus, there is not provided judging means for immediately judging whether or not the sputtering process in the film deposition apparatus 3 has been normally performed and an aluminum thin film has been satisfactorily deposited on the substrate 4. As shown in Figure 12, the film deposition apparatus 3 is incorporated in the manufacturing line consisting of the subsequent second handling machine 6 → a protective film-forming apparatus 7 → a third handling machine 8 → an inspection apparatus 9. Thus, the film-deposited substrate 4 will not be inspected until it reaches the final step of the manufacturing line, i.e., the inspection apparatus 9. In the inspection apparatus 9, automatic inspection items are processed which include a function test to automatically judge whether or not the information has been satisfactorily recorded on the CD. However, the items do not include an automatic inspection step to automatically inspect whether or not an aluminum thin film per se has been satisfactorily deposited. Assume that the results of such function test are satisfactory, however, the aluminum thin film per se has uneveness or black stains which damage the appearance beauties of the CD as merchandise. In this case, such CD must be removed as a defective product. Therefore, after the completion of the entire manufacturing processes, the whole manufactured CDs must undergo the prescribed visual inspection performed by human operators. In other words, even when an aluminum thin film has been unsatisfactorily deposited on the substrate 4 in the film deposition apparatus 3, such defective substrate 4 must pass through the subsequent processes including the protective film formation. This consumes wasteful time in the subsequent processes, and increases load on the final inspection process. Further, a large number of defective CDs might be produced, which cannot be discriminated in the final inspection process. As described above, in the conventional sputtering apparatus, there are not provided the judging means for immediately judging whether or not the prescribed film deposition by sputtering has been satisfactorily performed and the outputting means for outputting judgment-result signals corresponding to the substrate to be inspected. Thus, a large number of defective products might be unnecessarily transferred into subsequent processes. This inevitably deteriorates the yield of the products and decreases the efficiency of the manufacturing line.

## SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a sputtering apparatus which comprises abnormality-detecting means for immediately detecting the abnormalities in a sputtering

process, whereby the efficiency of the manufacturing line can be significantly increased.

Briefly, in accordance with one aspect of the present invention, there is provided a sputtering apparatus having a pressure-reduced film deposition chamber for depositing a thin film on the surface of a substrate to be processed, a target made of thin film-depositing material, the target being incorporated in the film deposition chamber at a position opposing to the substrate to be processed, and a power source for supplying discharge power across the substrate to be processed and the target. The improvement of the apparatus comprises necessary condition-determining means for determining conditions necessary for depositing a normal thin film on the surface of the substrate to be processed, executed result-detecting means for detecting the executed results of thin film-deposition processes, comparing means for comparing the executed results detected by the detected result-detecting means with the necessary conditions determined by the necessary condition-determining means, and judging means for judging whether or not the thin film-deposition process has been satisfactorily performed on the basis of the comparison results produced from the comparing means.

## BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figure 1 is a diagram illustrating the configuration of a manufacturing line in which a first embodiment of a sputtering apparatus according to the present invention has been employed;

Figure 2 is a block diagram illustrating an essential portion of the apparatus shown in Figure 1;

Figure 3 is a characteristic diagram illustrating the pressure and discharge power during the period of a single sputtering process for film deposition in the apparatus shown in Figure 1;

Figure 4 is a flow chart illustrating the operation procedures in the apparatus shown in Figure 1;

Figure 5 is a block diagram illustrating an essential portion of a second embodiment of a sputtering apparatus according to the present invention;

Figure 6 is a characteristic diagram illustrating the discharge power during the period of a single sputtering process for film deposition in the apparatus shown in Figure 5;

Figure 7 is a flow chart illustrating the operation procedures in the apparatus shown in Figure 5;

Figure 8 is a characteristic diagram illustrating the discharge power for sputtering in a third embodiment of a sputtering apparatus according to the present invention;

Figure 9 is a flow chart illustrating the operation procedures in the apparatus shown in Figure 8;

Figure 10 is a characteristic diagram illustrating the discharge power for sputtering in a fourth embodiment of a sputtering apparatus according to the present invention;

Figure 11 is a flow chart illustrating the operation procedures in the apparatus shown in Figure 10;

Figure 12 is a diagram illustrating the configuration of a conventional manufacturing line in which CDs are manufactured; and

Figure 13 is an enlarged cross-sectional view of the film deposition apparatus shown in Figure 12.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, several embodiments of a sputtering apparatus according to the present invention will be described with reference to the accompanying drawings, wherein like reference numerals designate identical or corresponding parts in the conventional apparatus shown in Figure 12 and Figure 13, whereby the detailed description thereof will be partially omitted.

Figure 1 is a diagram illustrating the configuration of a manufacturing line in which a first embodiment of a sputtering apparatus according to the present invention has been employed. In Figure 1, digital information of "1" or "0" is recorded on a substrate 4, which is made of synthetic resin, by use of a press-molding technique in a molding apparatus 1. The thus information-recorded substrate 4 is transferred by a first handling machine 2 into a film deposition apparatus 3. The film deposition apparatus 3 comprises a vacuum chamber in which an aluminum target 33 and the substrate 4 are disposed opposing to each other in the same manner as in the conventional apparatus. In the film deposition apparatus 3, an aluminum light-reflecting film is deposited on the surface of the substrate 4 by use of discharge power which is supplied from a power source 34 to the target 33. Further, a control unit 5 is connected both to the film deposition apparatus 3 and the power source 34. The control unit 5 comprises judging means 51 which is more specifically illustrated in Figure 2.

In Figure 2, a vacuum-sensing head 51a is provided in a film deposition chamber 31 (a vacuum chamber) of the film deposition apparatus 3. The pressure information in the film deposition chamber 31 is fed into a vacuum meter 51b so as

to be converted into a voltage signal Vp corresponding to the pressure in the film deposition chamber 31. The voltage signal Vp is fed into a controller 51c which is a microcomputer. In accordance with the programmed control, the controller 51c judges whether or not the pressure in the film deposition chamber 31, detected by the vacuum-sensing head 51a, has been a pressure necessary for the normal film deposition process. When this necessary pressure has not been present in the film deposition chamber 31, the controller 51c detects the abnormalities in sputtering. The thus detected result is fed into a second handling machine 6. As a result, the corresponding substrate 4 can be removed as a defective substrate from the second handling machine 6. Further, the removal of the defective substrate 4 is displayed on a display 52. A keyboard input unit 51d serves to determine the reference pressure value for the normal film deposition process, and to feed it into the controller 51c. The above-mentioned judgment result is outputted as signals corresponding to the substrate to be inspected.

Specifically, the second handling machine 6 removes the corresponding defective substrate 4 therefrom on the basis of a removal signal Q (which instructs to remove a substrate having a defective thin film deposited thereon) produced from the judging means 51. Thus, only the substrate 4, on which an aluminum thin film has been satisfactorily deposited by the normal sputtering process, can be transferred into a protective film-forming apparatus 7. In the apparatus 7, a synthetic resin protective film is formed on the aluminum film-deposited surface of the thus transferred substrate 4.

In the manufacturing line starting with the molding apparatus 1 through an inspection apparatus 9, the film deposition apparatus 3 is the most essential apparatus of all. Specifically, in the molding apparatus 1, the substrates are manufactured by use of a press-molding technique. Thus, the substrates of uniformed quality can be relatively easily obtained, i.e., few substrates having a defective molded shape are produced. Further, in the protective film-forming apparatus 7, synthetic resin is simply painted on the aluminum film-deposited surface of the substrates, and hardened by ultraviolet rays applied thereto. Thus, also in this process, the rate of producing defective substrates is relatively low. However, in the film deposition apparatus 3, complicated and accurately controlled processes are repeatedly performed in a sheet-by-sheet mass-production manner. Such complicated processes include : transferring substrates into the vacuum chamber → exhaust by use of a turbo molecule pump → discharge (sputtering process) → transferring substrates to the outside. Thus, the rate of producing defective substrates is the highest throughout the processes in the manufacturing line. In the first embodiment according to the present invention, the judging means 51 is provided in the control unit 5. The judging means 51 can immediately judge whether or not an aluminum thin film has been satisfactorily deposited on an individual substrate. The second handling machine 6 receives the judgment result from the judging means 51 in the control unit 5. Thus, the defective substrate can be removed from the second handling machine 6. As a result, the load on the inspection apparatus 9 can be reduced, and wasteful time, in which a protective film is formed on the defective substrate, can be eliminated.

More specifically, a single film deposition process, which includes exhaust → film deposition (sputtering process) → transfer, is performed in a short-period of about 6 seconds, as shown in Figure 3. In Figure 3, the solid line A represents pressure in the film deposition chamber 31, and the dotted line B represents DC power applied across the target 33 and the substrate 4. An aluminum thin film is satisfactorily deposited on the substrate 4 only when the pressure A in the film deposition chamber 31 has been sufficiently decreased by exhaust. Thus, in general, the DC power B for sputtering is applied only after the sufficient decrease of the pressure A has been confirmed. In other words, the pressure in the film deposition chamber 31 must be detected immediately before the sputtering. This is disadvantageous to the reduction of the sheet-by-sheet processing time. Thus, in this embodiment, the pressure in the film deposition chamber 31 is detected at a time after the film deposition, i.e., at a time during the transferring period. When the thus detected pressure value is equal to or less than a predetermined reference value, the judging means 51 recognizes that a satisfactory film deposition process has been performed under the normal pressure.

The controller 51c, which is a microcomputer incorporated in the judging means 51, derives a sputtering completion signal Ts at a time after the sputtering film deposition process, i.e., at a time during the transferring period. Previously, an allowable maximum pressure value Pr [Pa] at the time upon the occurrence of the signal Ts has been fed into the controller 51c as a reference value by use of the keyboard input unit 51d. The judgment as to whether or not the prescribed film deposition process has been satisfactorily performed is executed in accordance with the following simple procedures shown in Figure 4.

In STEP (a), the procedure converts a voltage signal Vp (e.g., in a range of Ov through 11 v) produced from the vacuum meter 51b into a pres-

sure value Ps [Pa]. In STEP (b), the procedure compares the detected pressure value Ps [Pa] with the reference pressure value Pr [Pa], and judges whether or not Ps ≦ Pr. This comparison is made at the time upon the occurrence of the sputtering completion signal Ts in very film deposition processes. When Ps ≦ Pr the procedure recognizes that the prescribed film deposition process has been satisfactorily performed. However, when Ps > Pr, the procedure recognizes that the corresponding substrate 4 is defective in terms of the film deposition. In this case, the procedure produces an abnormality-indicating signal corresponding to each substrate to be inspected and also indicates this on the display 52. Further, the procedure feeds the removal signal Q into the second handling machine 6. As a result, the corresponding defective substrate 4 can be removed from the second handling machine 6.

As described above, the sputtering apparatus according to this embodiment comprises the judging means 51 that can judge whether or not the prescribed film deposition process has been satisfactorily performed. This judgment is made on the basis of whether or not the pressure in the film deposition chamber has been normal value during the film deposition period. Thus, the corresponding defective substrate can be removed from the manufacturing line at the earliest possible step, i.e., from the second handling machine 6. As a result, the load of the final inspection apparatus 9 in the manufacturing line can be reduced. Further, the wasteful processes including the protective film-formation with respect to the defective substrates can be avoided. Therefore, the efficiency of the manufacturing line can be significantly enhanced.

In the above-described first embodiment according to the present invention, the condition, in which a substrate having a defective film deposited thereon is produced, has been defined as the case when the film deposition process has been performed under the abnormal pressure. However, the defective film deposition or the damage to the pits can also occur in the case when the waveform of discharge power (voltage or current), being applied in a pulse-shaped manner during the film deposition process, has not been in a prescribed normal shape. Thus, the abnormalities in sputtering can also be detected by the detection of the abnormal waveform of such discharge power (voltage or current).

Next, a second embodiment of a sputtering apparatus according to the present invention will be described with reference to Figure 5 through Figure 7. In this embodiment, when the discharge power waveform has not been normal, i.e., when the sufficient discharge power necessary for the normal film deposition process has not been applied, the apparatus produces an abnormality-indicating signal corresponding to the each substrate to be inspected which indicates that a defective substrate has been produced in the film deposition process. The entire manufacturing line, in which this embodiment of the sputtering apparatus has been employed, has the same configuration as that shown in Figure 1 and Figure 2. However, the power source 34 has a configuration shown in Figure 5. In Figure 5, the power source 34 receives 3-phase AC power, and converts the same into high-voltage DC power by use of an AC-DC converter 34a incorporated therein. The thus converted high-voltage DC power is supplied to the film deposition apparatus 3. The AC-DC converter 34a produces the DC power output in accordance with an output timing signal supplied from a control circuit board 34b. The output timing signal has been appropriately determined so as to perform the prescribed film deposition process. Further, a DC output power value Pa and a DC output voltage value Pr, which represent the converted output, are detected by use of a combination of components such as a resistor 34c, a voltage detection circuit 34ba and a current detection circuit 34bb. The thus detected values Pa and Pr are fed into the judging means 51 in the control unit 5. Thus, the judging means 51 can judge whether or not the prescribed film deposition process has been satisfactorily performed. Moreover, the power source 34 produces a spark signal Pk upon the detection of that an are discharge (abnormal discharge) has occurred during the sputtering process instead of a glow discharge (normal discharge). The spark signal Pk is also fed into the judging means 51 in the control unit 5, as shown in Figure 5.

The judging means 51 feeds a discharge starting signal Hk and a discharge-stop controlling signal Ht into the power source 34. The power source 34 then feeds an analog-detection output signal (Pa) corresponding to its output DC power into the judging means 51. In Figure 6, the rectangular waveform indicated by the dotted line B represents the prescribed DC output power to achieve the satisfactory film deposition. Assume that the analog-detection output signal (Pa) has a waveform indicated by the solid line C. This represents that the prescribed DC output power has not been supplied to the film deposition apparatus 3. Specifically, the total amount of times T1 and T2, in which the discharge power has not reached a minimum output power value Pt during a single sputtering process, has exceeded a predetermined constant time period L. In this case, the judging means 51 recognizes that the prescribed discharge power necessary for the normal film deposition process has not been supplied, and judges that the prescribed film deposition process has not been sat-

isfactorily performed, and then feeds an abnormality-detection signal Q corresponding to the each substrate to be inspected into the second handling machine 6. Thus, a corresponding substrate having a defective thin film deposited thereon can be removed from the second handling machine 6.

The programmed control procedures with respect to the above-described operations in the judging means 51 will be described with reference to a flow chart shown in Figure 7. In STEP (a) and in STEP (b), the procedure respectively predetermines a prescribed DC output value Pm and a reference DC output value Pt. In STEP (c), the procedure receives the analog-detection output signal Pa from the power source 34. In STEP (d), the procedure converts the thus received analog signal Pa into a digital signal. In STEP (e), the procedure calculates the total amount of time in which Pt ≥ Pa, i.e., the cause to prevent the normal film deposition process. In STEP (f), the procedure predetermines the discharge time period L necessary for the prescribed film deposition process. In STEP (g), the procedure calculates an actual total amount of time in which Pt ≥ Pa during a single film deposition process. In STEP (h), the procedure judges whether or not the thus calculated actual total amount of time has exceeded the predetermined time period L. In the case of YES, the procedure then produces an abnormality-detection signal Q, and feeds it to the second handling machine 6. Further, the procedure indicates this abnormality on the display 52. Therefore, when the above-described second embodiment is employed in a series of manufacturing line processes, a substrate having a defective thin film deposited thereon can be removed from the line at the earliest possible step, i.e., at the second handling machine 6. This can be performed in the same manner as in the first embodiment. Thus, the load on the final inspection apparatus 9 can be reduced, and the wasteful processes in the line with respect to the defective substrates can be avoided.

Moreover, there can be provided another technique to judge whether or not the prescribed film deposition process has been satisfactorily performed on the basis of the detection results of whether or not the normal discharge has been performed during the film deposition process. Specifically, the technique is such that the total amount of time, in which the instantaneous discharge interruption (caused by are discharge and the like) has occurred during a single film deposition process, is compared with a predetermined allowable time. Further, when the total amount of time has exceeded the predetermined allowable time, the judging means 51 recognizes that the prescribed film deposition process has not been satisfactorily performed. The judging means 51 then produces an abnormality-detection signal. This technique is useful because even the instantaneous discharge interruption would have some adverse effect on the film deposition process which is performed in an extremely short period of about 2 seconds.

Next, a third embodiment of a sputtering apparatus according to the present invention, in which the above-described technique is utilized, will be described with reference to Figure 8 and Figure 9. Figure 8 shows the waveform of the discharge power, and Figure 9 shows the programmed procedures in the judging means 51. In Figure 8, T3 and T4 respectively represent the times in which the instantaneous discharge interruption has occurred during a single film deposition process. The judging means 51 compares the total amount of such times, i.e., Tc = T3 + T4, with a predetermined reference time period L1, and judges whether or not Tc > L1 . When Tc > L1, the judging means 51 then produces an abnormality-detection signal Q indicating that the entire normal discharge power has been insufficient for the satisfactory film deposition process. The programmed procedures shown in Figure 9 are substantially the same as those in the second embodiment shown in Figure 7, so that the detailed description thereof will be omitted. In Figure 9, the procedure predetermines the reference time period L1 (STEP(i)), and starts the discharge (STEP (j)). Thereafter, the procedure calculates the total amount of time, Tc = T3 + T4 - (STEP (k)). In STEP (1), the procedure judges whether or not Tc > L1. When Tc > L1, the procedure recognizes that the prescribed film deposition process has not been satisfactorily performed, and produces the abnormality-detection signal Q, which is fed into the second handling machine 6. Thus, a substrate having a defective thin film deposited thereon can be removed from the second handling machine 6. Further, the procedure indicates such abnormality on the display 52.

Moreover, assume that the number of times of instantaneous discharge interruptions (caused by arc discharge and the like) in a single film deposition process has exceeded a predetermined allowable number. In this case, a prescribed thin film cannot be satisfactorily deposited on the surface of a substrate, and the pits formed thereon might be damaged. This phenomenon occurs because of the fact that the excessive number of times of instantaneous discharge interruptions causes aluminum to be scattered in massive particles from the parts such as an aluminum target, a protective shield and the like. Upon the detection of the excessive number of times of instantaneous discharge interruptions, the judging means 51 recognizes that unsatisfactory film deposition process has been performed, and produces an abnormality-detection

signal.

Next, a fourth embodiment of a sputtering apparatus according to the present invention, in which the above-described phenomenon has been taken into consideration, will be described with reference to Figure 10 and Figure 11. Figure 10 shows the waveform of the discharge power, and Figure 11 shows the programmed procedures in the judging means 51. In Figure 10, instantaneous discharge interruptions (caused by spark) have occurred five times (t1 through t5) during a single film deposition process. The judging means 51 counts the number of times of the instantaneous discharge interruptions, and compares the thus counted number n with a predetermined reference number of times L2. When n > L2, the judging means 51 then produces an abnormality-detection signal Q because of that the damage to the surface of the substrate 4 cannot be neglected even when the entire discharge power has been sufficient to achieve the prescribed film deposition process. In Figure 11, the procedure predetermines the reference number of times of instantaneous discharge interruptions (STEP (m)). After the discharge has been started, several spark signals Pk (indicating the occurrence of instantaneous discharge interruptions) are produced from the power source 34. The procedure counts the number of times n of the instantaneous discharge interruptions on the basis of the thus produced spark signals Pk (STEP (n)). The procedure judges whether or not the thus counted number n is greater than or equal to the reference number L2. When n ≧ L2, the procedure then produces an abnormality-detection signal Q, and feeds it both to the second handling machine 6 and the display 52 (STEP (o)).

In the above-described first through fourth embodiments, the power source 34 has been described as the DC power source. However, the power source 34 can also be replaced with a high frequency power source. In this case, the same advantages as those in the above-described embodiments can also be obtained. Further, in the second through fourth embodiments, the waveform of the output power Pa has been utilized to judge whether or not the prescribed film deposition process has been satisfactorily performed. However, the waveform of the output voltage Pr may also be utilized for the same judgment. Moreover, the abnormality-detection signal Q may also be fed into the third handling machine 8. Further, in the respective above-described embodiments, various parameters, which are discharge power, discharge interruption time, the number of times of arc discharges and the discharge voltage value or the discharge current value, are independently and individually detected to be utilized as the basis of the abnormality-detection of the sputtering process. However, such parameters may also be appropriately selected so as to make a combination thereof, or all of the parameters may also be provided in the apparatus. Namely, in some cases, all of the above-described embodiments can be incorporated in the sputtering apparatus, the abnormality detection of the sputtering film deposition process can be performed either on the basis of a parameter of any one of the embodiments, or on the basis of a combination of plural parameters of the embodiments incorporated in the apparatus.

As described above, according to the present invention, there can be provided a sputtering apparatus that can judge, immediately after the completion on a film deposition process, whether or not the film deposition process has been satisfactorily performed, and can produce an abnormality-detection signal. Thus, when the sputtering apparatus of this invention is incorporated in a mass-production manufacturing line, a substrate having a defective film in terms of function and/or appearance, which cannot be detected by the conventional inspection apparatus, can be removed from the line at the earliest possible step. This is significantly advantageous, and contributes much to the improvement of the efficiency of the manufacturing line. The apparatus of this invention can also be utilized even for a single sputtering process, i.e., a sputtering apparatus for various objects such as a glass plate, a metal plate, plastics and the like. The sputtering apparatus according to the present invention having a simple configuration can assuredly detect the abnormalities in the film deposition process with respect to an individual substrate at the earliest possible step in the continuous manufacturing line. Thus, the apparatus is significantly advantageous to the practical applications.

Obviously, numerous additional modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claimes, the invention may be practiced otherwise than as specifically described herein.

## Claims

1. A sputtering apparatus having a pressure-reduced film deposition chamber (31) for depositing a thin film on the surface of a substrate (4) to be processed, a target (33) made of thin film-depositing material being incorporated in said film deposition chamber (31) at a position opposing to said substrate (4) to be processed and a power source (34) for supplying discharge power across said substrate (4) to be processed and said target (33), characterized in that the sputtering apparatus further comprises :

necessary condition-determining means for determining conditions necessary for depositing a normal thin film on the surface of said substrate to be processed;

executed result-detecting means for detecting the executed results of a thin film-deposition process;

comparing means for comparing the executed results detected by said executed result-detecting means; and

judging means for judging whether or not said thin film-deposition process has been satisfactorily performed on the basis of the comparison results produced from said comparing means.

2. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining a reference pressure value in said film deposition chamber, and said executed result-detecting means includes means for detecting the executed pressure value in said film deposition chamber during the film deposition process.

3. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining the necessary time period of a prescribed discharge power value, and said executed result-detecting means includes means for detecting the total amount of the executed discharge time period in which the executed discharge power value has not reached said prescribed discharge power value.

4. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining the allowable time period of discharge interruption, and said executed result-detecting means includes means for detecting the executed time period of discharge interruption.

5. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining the allowable number of times of arc discharges, and said executed result-detecting means includes means for detecting executed number of times of arc discharges.

6. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining the necessary time period of a prescribed discharge voltage value, and said executed result-detecting means includes means for detecting the total amount of the executed discharge time period in which the executed discharge voltage value has not reached said prescribed discharge voltage value.

7. The sputtering apparatus of claim 1, wherein said necessary condition-determining means includes means for determining the necessary time period of a prescribed discharge current value, and said executed result-detecting means includes means for detecting the total amount of the executed discharge time period in which the executed discharge current value has not reached said prescribed discharge current value.

8. The sputtering apparatus of anyone of claims 1 to 7, wherein said judging means outputs the judgment result as the signal corresponding to said substrate.

9. The sputtering apparatus of claim 1, characterized in that it comprises:

first necessary condition-determining means for determining a reference pressure value in said film deposition chamber, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

second necessary condition-determining means for determining the necessary time period of a prescribed discharge power value, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

third necessary condition-determining means for determining the allowable time period of discharge interruption, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

fourth necessary condition-determining means for determining the allowable number of times of arc discharges, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

fifth necessary condition-determining means for determining the necessary time period of a prescribed discharge voltage value, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

sixth necessary condition-determining means for determining the necessary time period of a prescribed discharge current value, being necessary for depositing a normal thin film on the surface of said substrate to be processed;

first executed result-detecting means for detecting the executed pressure value during

the sputtering process;

second executed result-detecting means for detecting the total amount of the executed discharge time period in which the executed discharge power value has not reached said prescribed discharge power value;

third executed result-detecting means for detecting the executed time period of discharge interruption;

fourth executed result-detecting means for detecting the executed number of times of arc discharges;

fifth executed result-detecting means for detecting the total amount of the executed discharge time period in which the executed discharge voltage value has not reached said prescribed discharge voltage value;

sixth executed result-detecting means for detecting the total amount of the executed discharge time period in which the executed discharge current value has not reached said prescribed discharge current value;

first comparing means for comparing the executed results detected by said first executed result-detecting means with the necessary conditions determined by said first necessary condition-determining means;

second comparing means for comparing the executed results detected by said second executed result-detecting means with the necessary conditions determined by said second necessary condition-determining means;

third comparing means for comparing the executed results detected by said third executed result-detecting means with the necessary conditions determined by said third necessary condition-determining means;

fourth comparing means for comparing the executed results detected by said fourth executed result-detecting means with the necessary conditions determined by said fourth necessary condition-determining means;

fifth comparing means for comparing the executed results detected by said fifth executed result-detecting means with the necessary conditions determined by said fifth necessary condition-determining means;

sixth comparing means for comparing the executed results detected by said sixth executed result-detecting means with the necessary conditions determined by said sixth necessary condition-determining means; and

judging means for judging whether or not a prescribed film deposition process has been satisfactorily performed on the basis of at least one of the comparison results produced from said first through sixth comparing means. 10. The sputtering apparatus of claim 9 , wherein said judging means outputs the judgment result as the signal corresponding to said substrate.

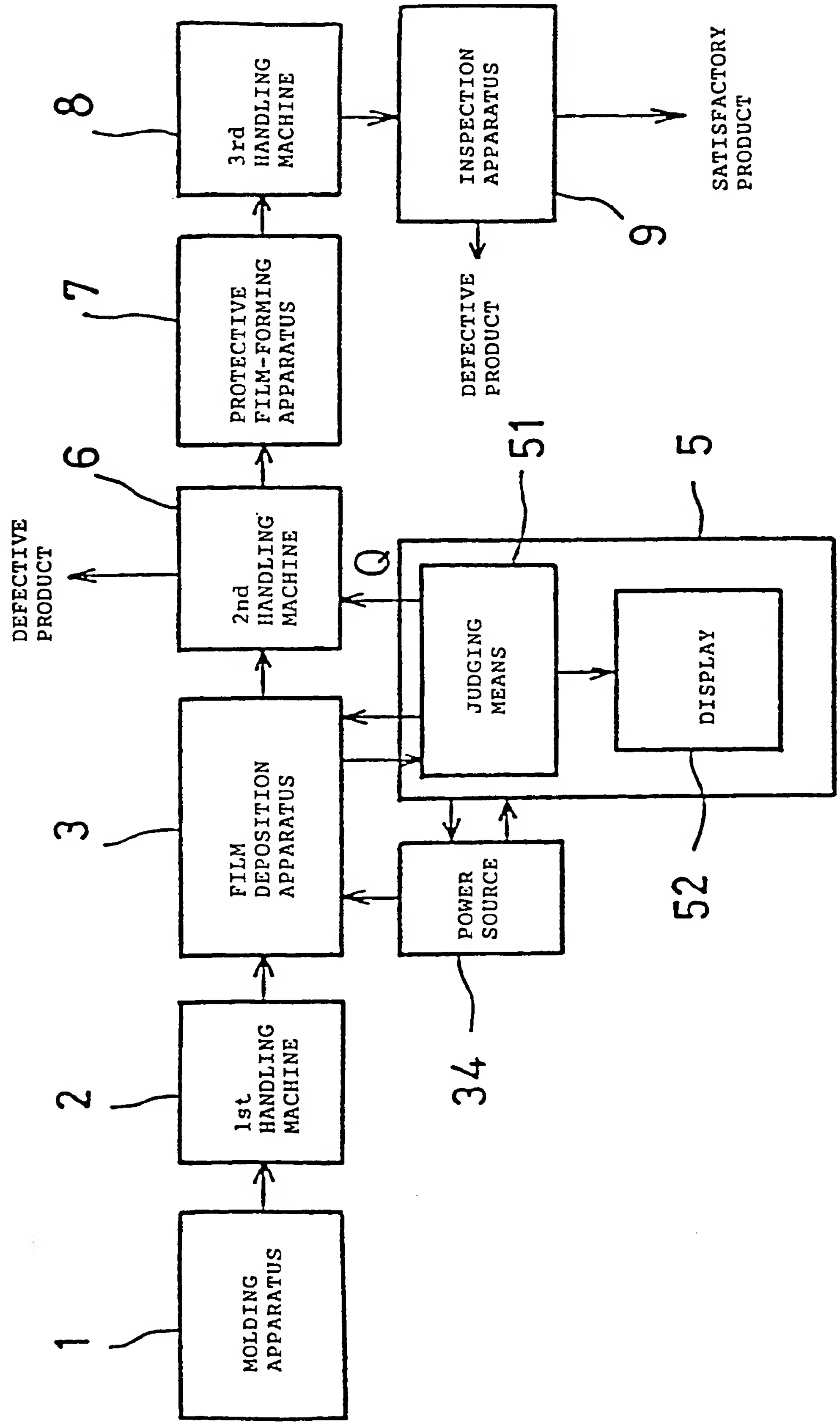
1
MOLDING APPARATUS
2
1st HANDLING MACHINE
3
FILM DEPOSITION APPARATUS
6
2nd HANDLING MACHINE
DEFECTIVE PRODUCT
7
PROTECTIVE FILM-FORMING APPARATUS
8
3rd HANDLING MACHINE
INSPECTION APPARATUS
9
SATISFACTORY PRODUCT
DEFECTIVE PRODUCT
34
POWER SOURCE
5
51
JUDGING MEANS
52
DISPLAY
Q

FIG. 1

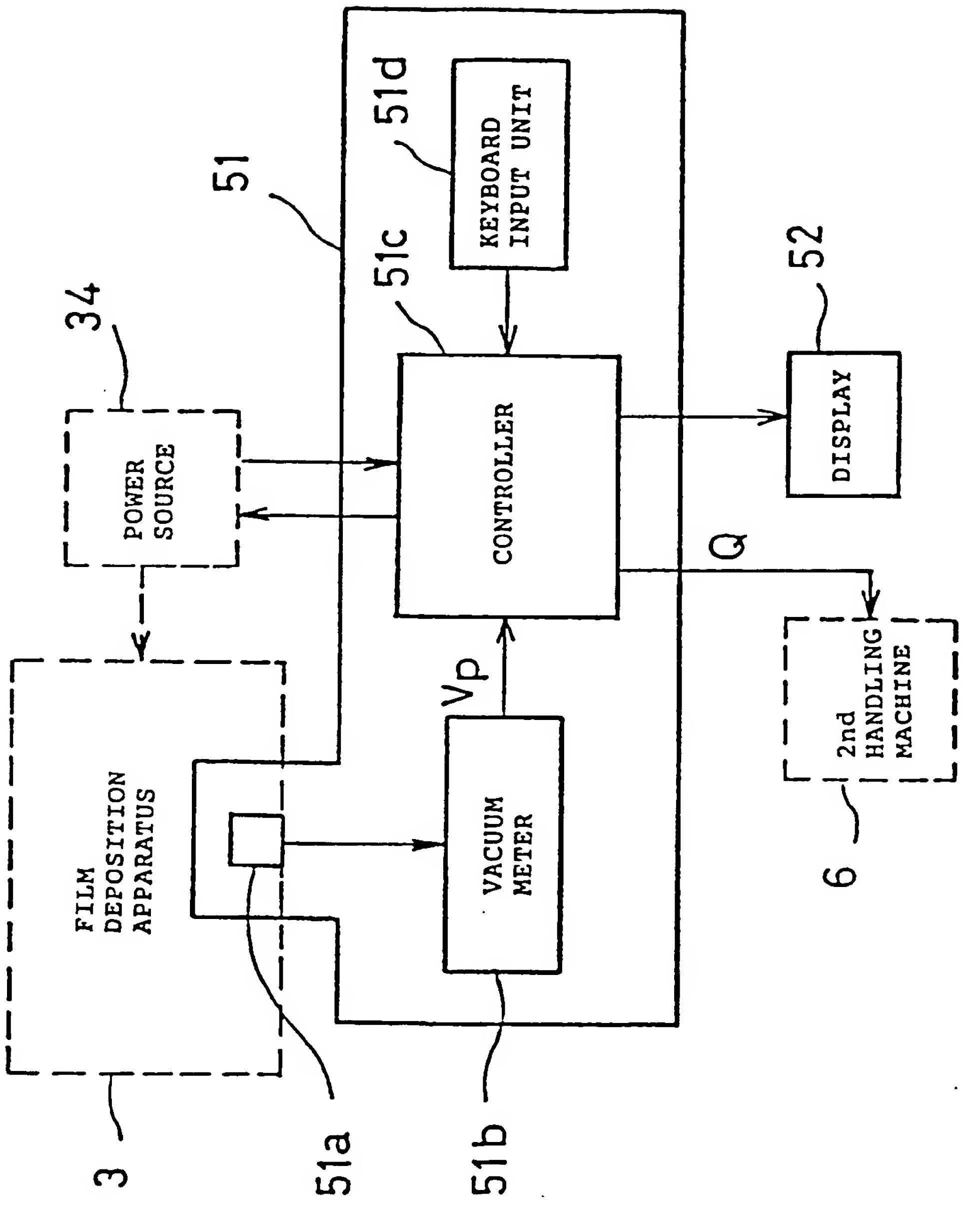
FILM DEPOSITION APPARATUS
POWER SOURCE
CONTROLLER
KEYBOARD INPUT UNIT
DISPLAY
VACUUM METER
2nd HANDLING MACHINE
Vp
Q
3
34
51
51a
51b
51c
51d
52
6

FIG. 2

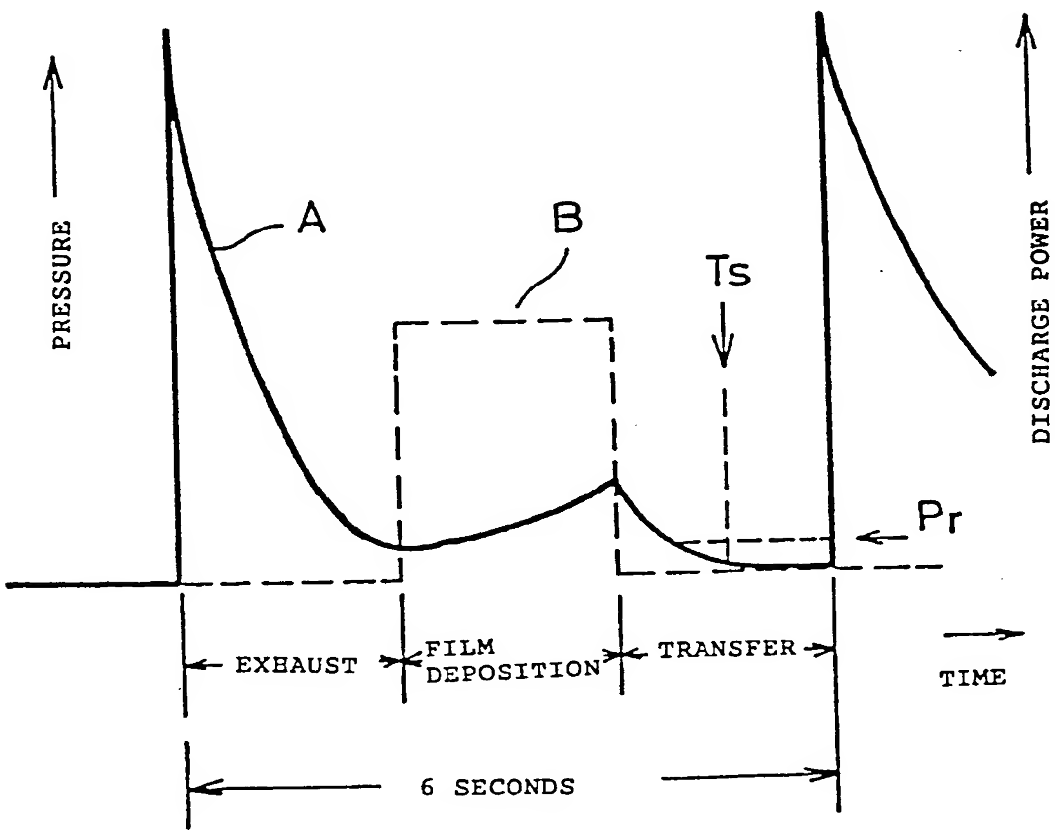
PRESSURE
A
B
Ts
DISCHARGE POWER
Pr
EXHAUST
FILM DEPOSITION
TRANSFER
TIME
6 SECONDS

FIG. 3

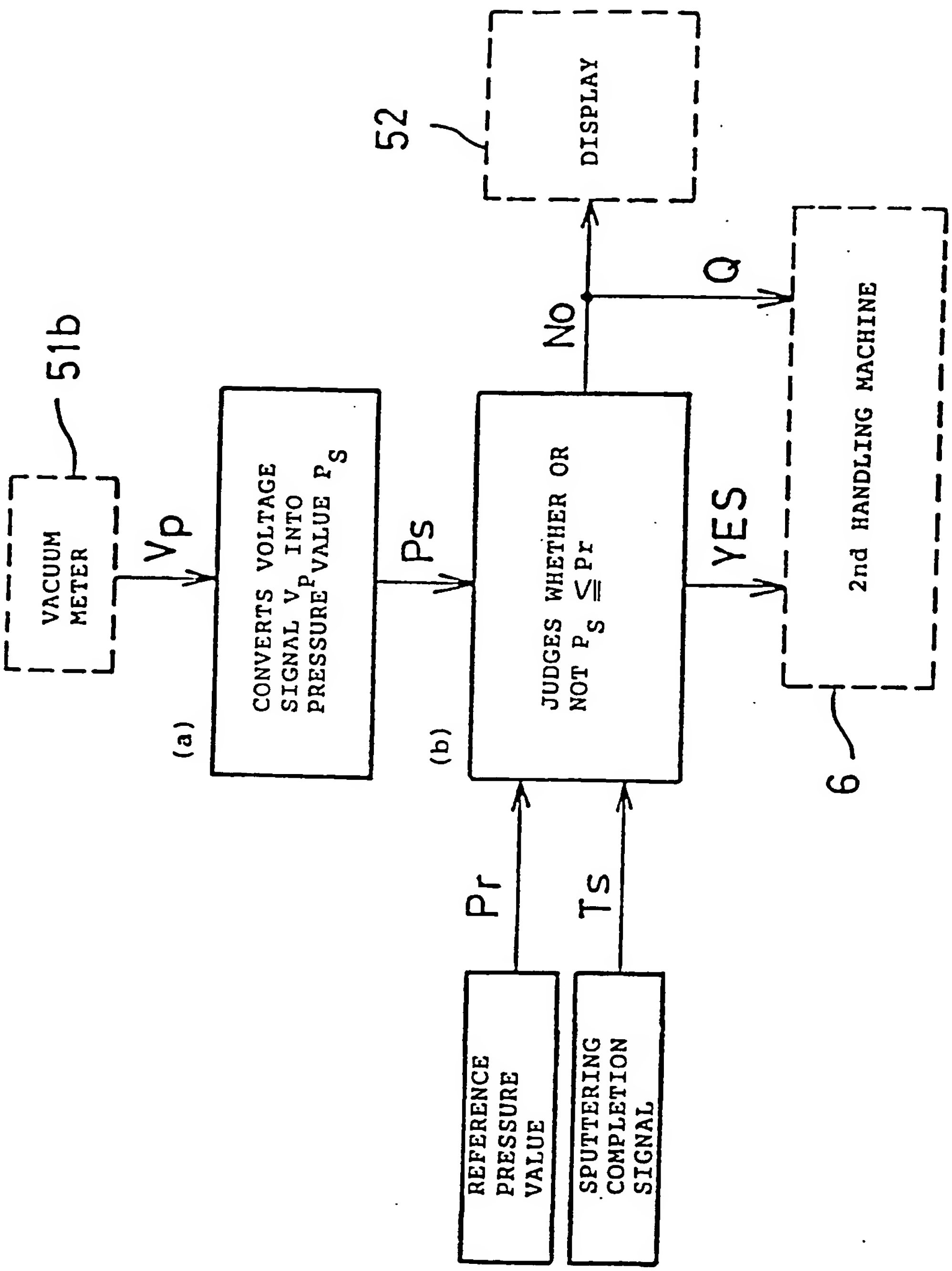
51b
VACUUM METER
Vp
(a)
CONVERTS VOLTAGE SIGNAL $V_P$ INTO PRESSURE VALUE $P_S$
Ps
(b)
JUDGES WHETHER OR NOT $P_S \leqq P_r$
No
52
DISPLAY
Q
YES
2nd HANDLING MACHINE
6
Pr
Ts
REFERENCE PRESSURE VALUE
SPUTTERING COMPLETION SIGNAL

FIG. 4

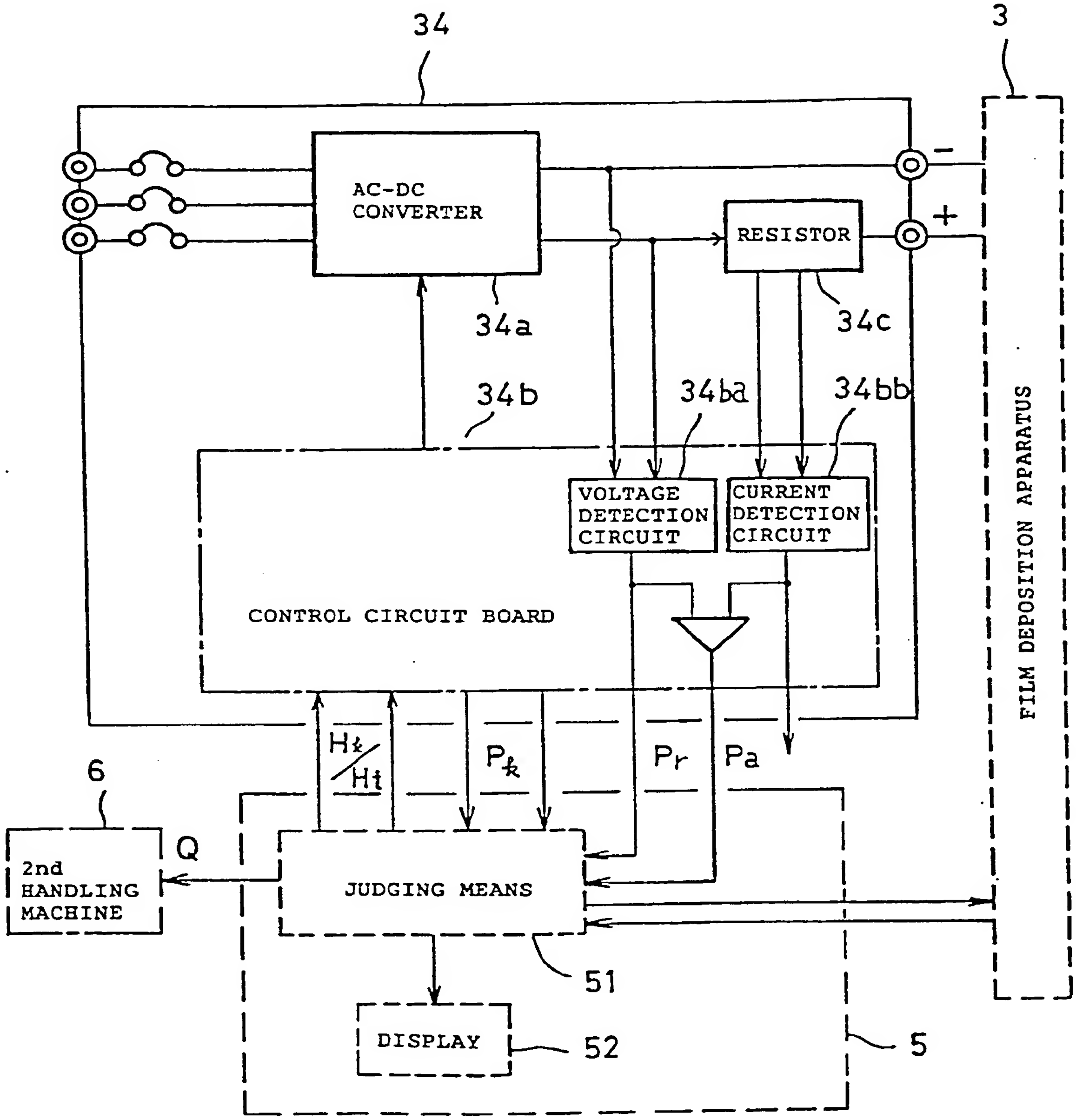
34
3
AC-DC
CONVERTER
RESISTOR
34a
34c
34b
34ba
34bb
VOLTAGE
DETECTION
CIRCUIT
CURRENT
DETECTION
CIRCUIT
CONTROL CIRCUIT BOARD
FILM DEPOSITION APPARATUS
Pr
Pa
6
Q
2nd
HANDLING
MACHINE
JUDGING MEANS
51
DISPLAY
52
5

FIG. 5

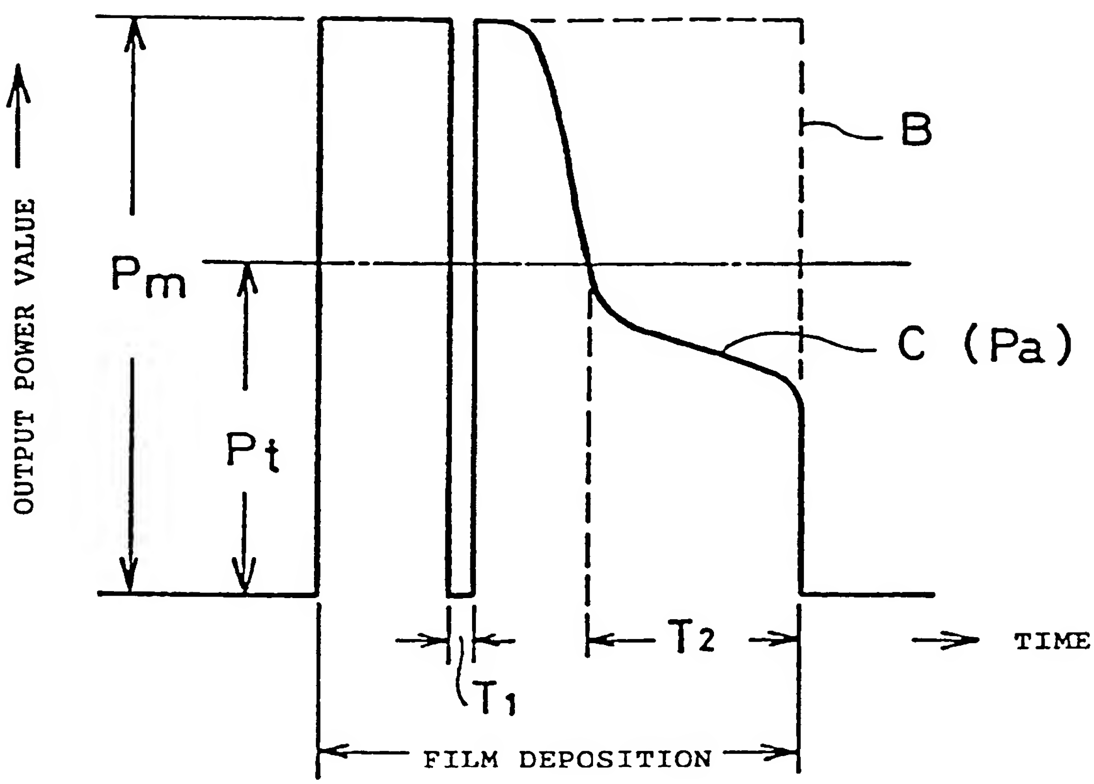


FIG. 6

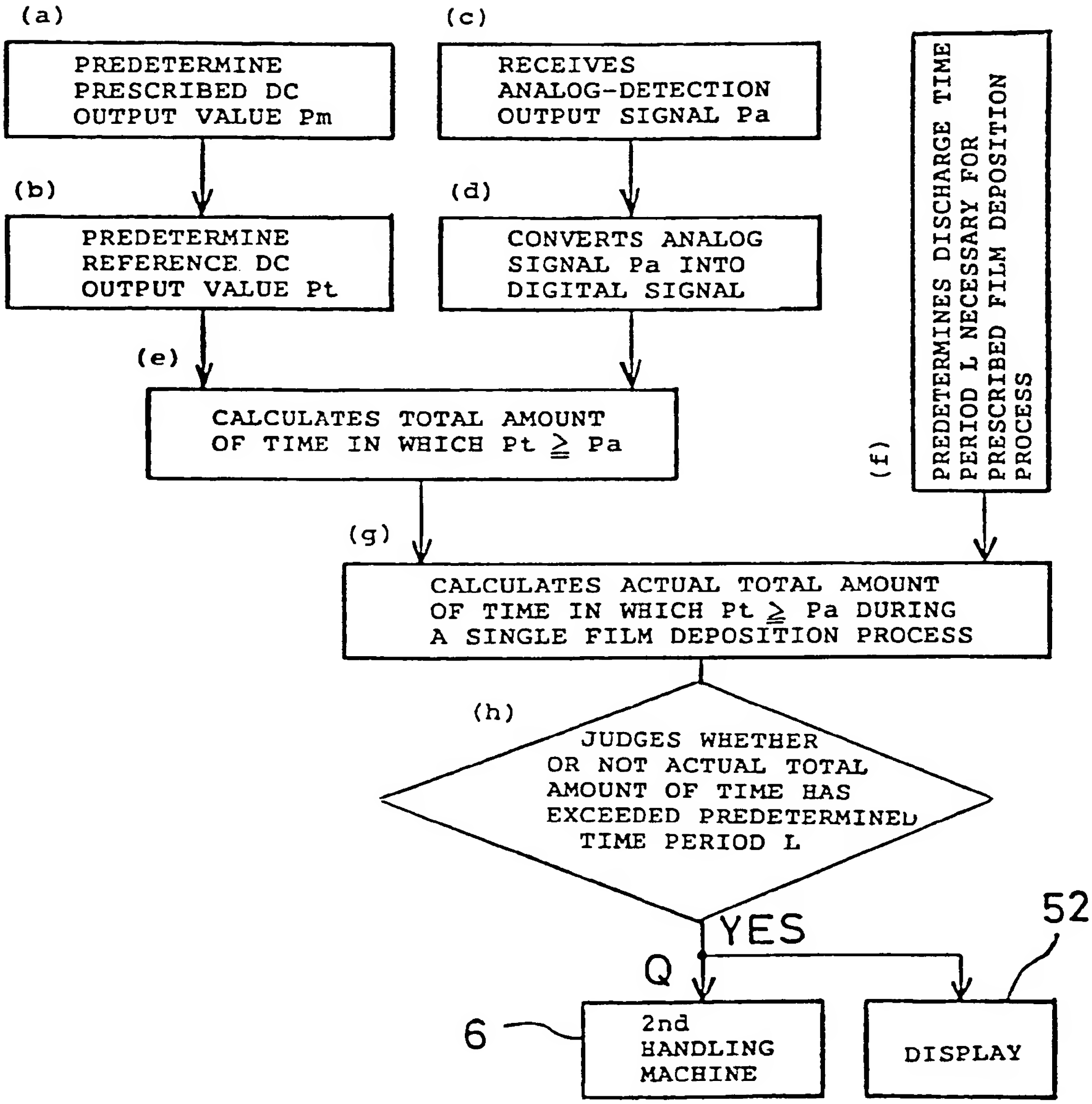
(a)
PREDETERMINE PRESCRIBED DC OUTPUT VALUE Pm
(b)
PREDETERMINE REFERENCE DC OUTPUT VALUE Pt
(c)
RECEIVES ANALOG-DETECTION OUTPUT SIGNAL Pa
(d)
CONVERTS ANALOG SIGNAL Pa INTO DIGITAL SIGNAL
(e)
CALCULATES TOTAL AMOUNT OF TIME IN WHICH Pt ≧ Pa
(f)
PREDETERMINES DISCHARGE TIME PERIOD L NECESSARY FOR PRESCRIBED FILM DEPOSITION PROCESS
(g)
CALCULATES ACTUAL TOTAL AMOUNT OF TIME IN WHICH Pt ≧ Pa DURING A SINGLE FILM DEPOSITION PROCESS
(h)
JUDGES WHETHER OR NOT ACTUAL TOTAL AMOUNT OF TIME HAS EXCEEDED PREDETERMINED TIME PERIOD L
YES
Q
52
6
2nd HANDLING MACHINE
DISPLAY

FIG. 7

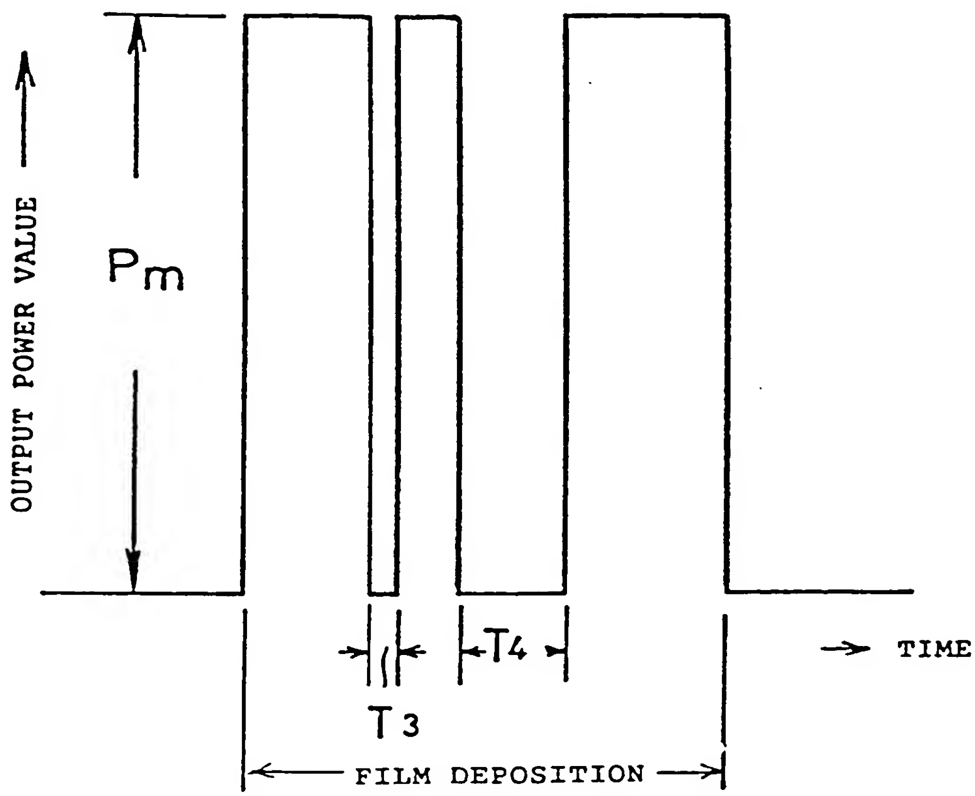


FIG. 8

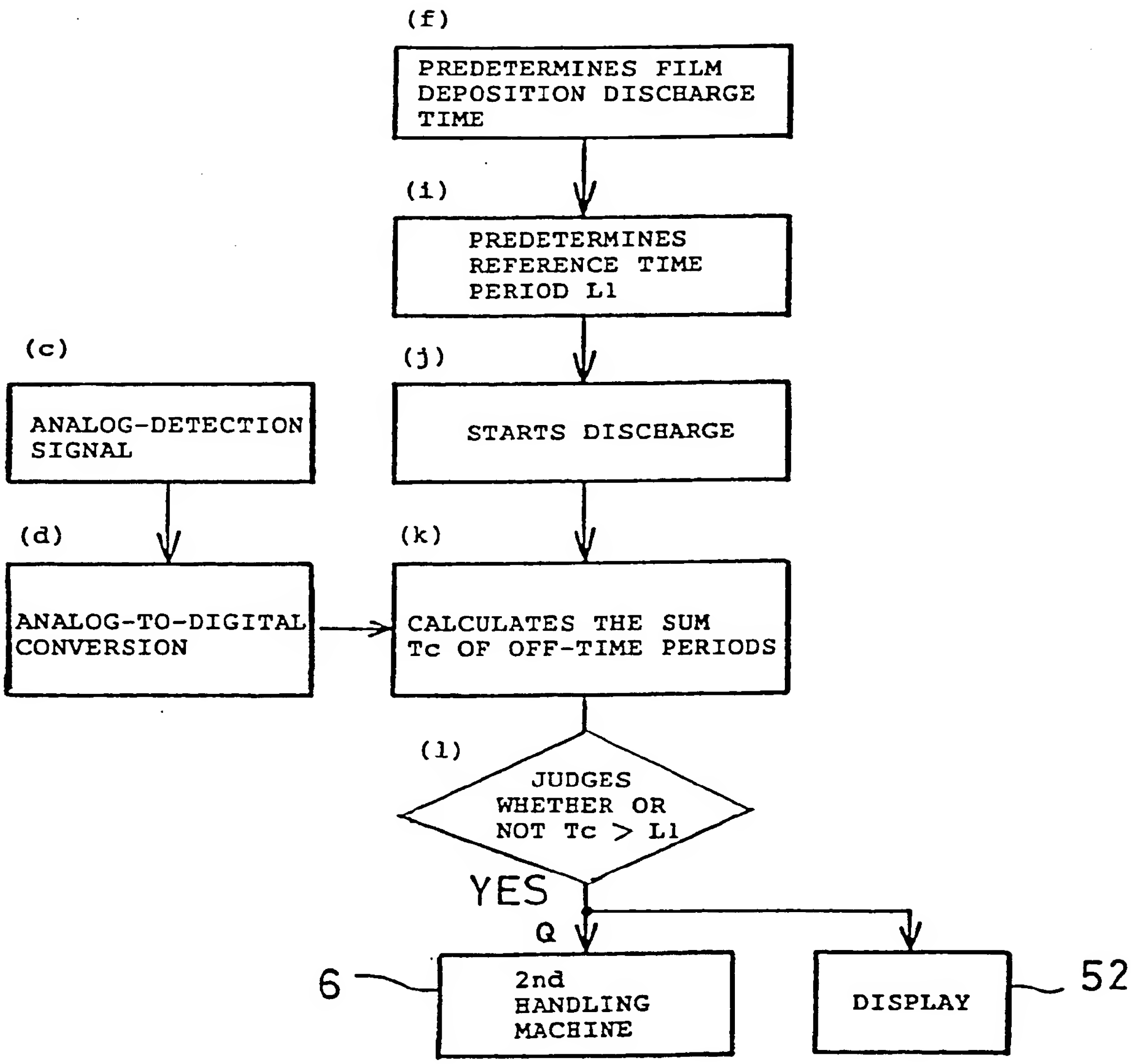
(f)
PREDETERMINES FILM DEPOSITION DISCHARGE TIME
(i)
PREDETERMINES REFERENCE TIME PERIOD L1
(j)
STARTS DISCHARGE
(c)
ANALOG-DETECTION SIGNAL
(d)
ANALOG-TO-DIGITAL CONVERSION
(k)
CALCULATES THE SUM Tc OF OFF-TIME PERIODS
(l)
JUDGES WHETHER OR NOT Tc > L1
YES
Q
6
2nd HANDLING MACHINE
DISPLAY
52

FIG. 9

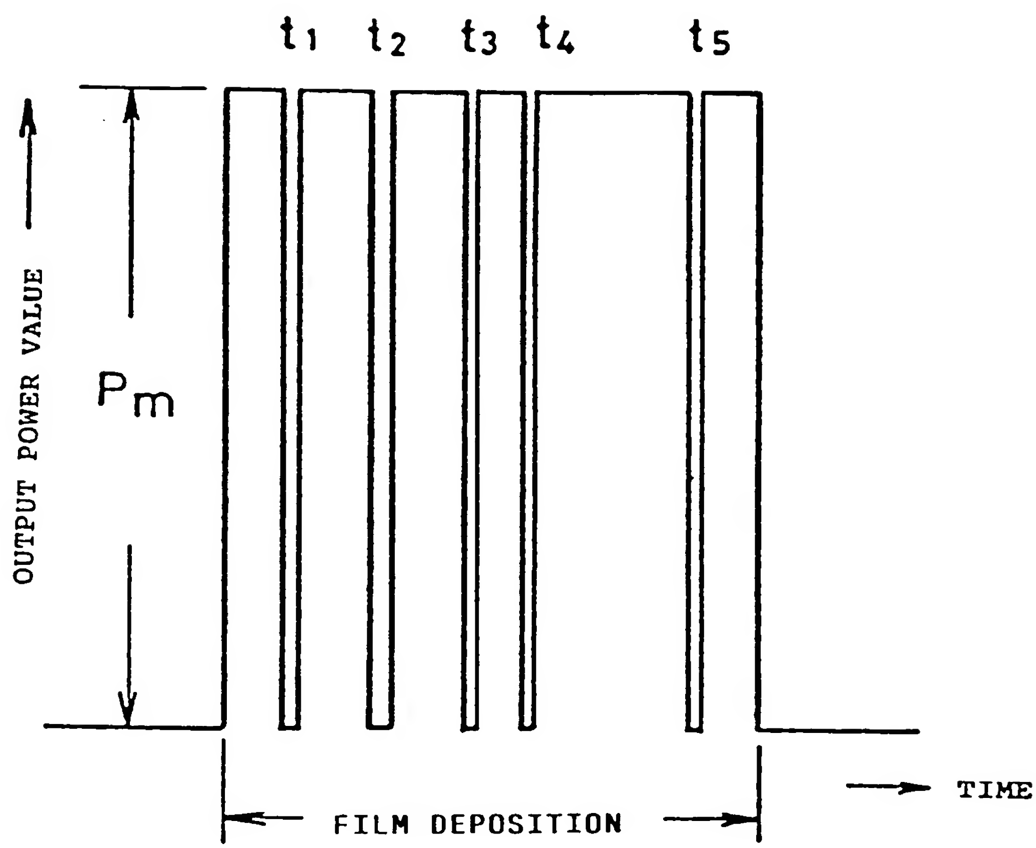


FIG. 10

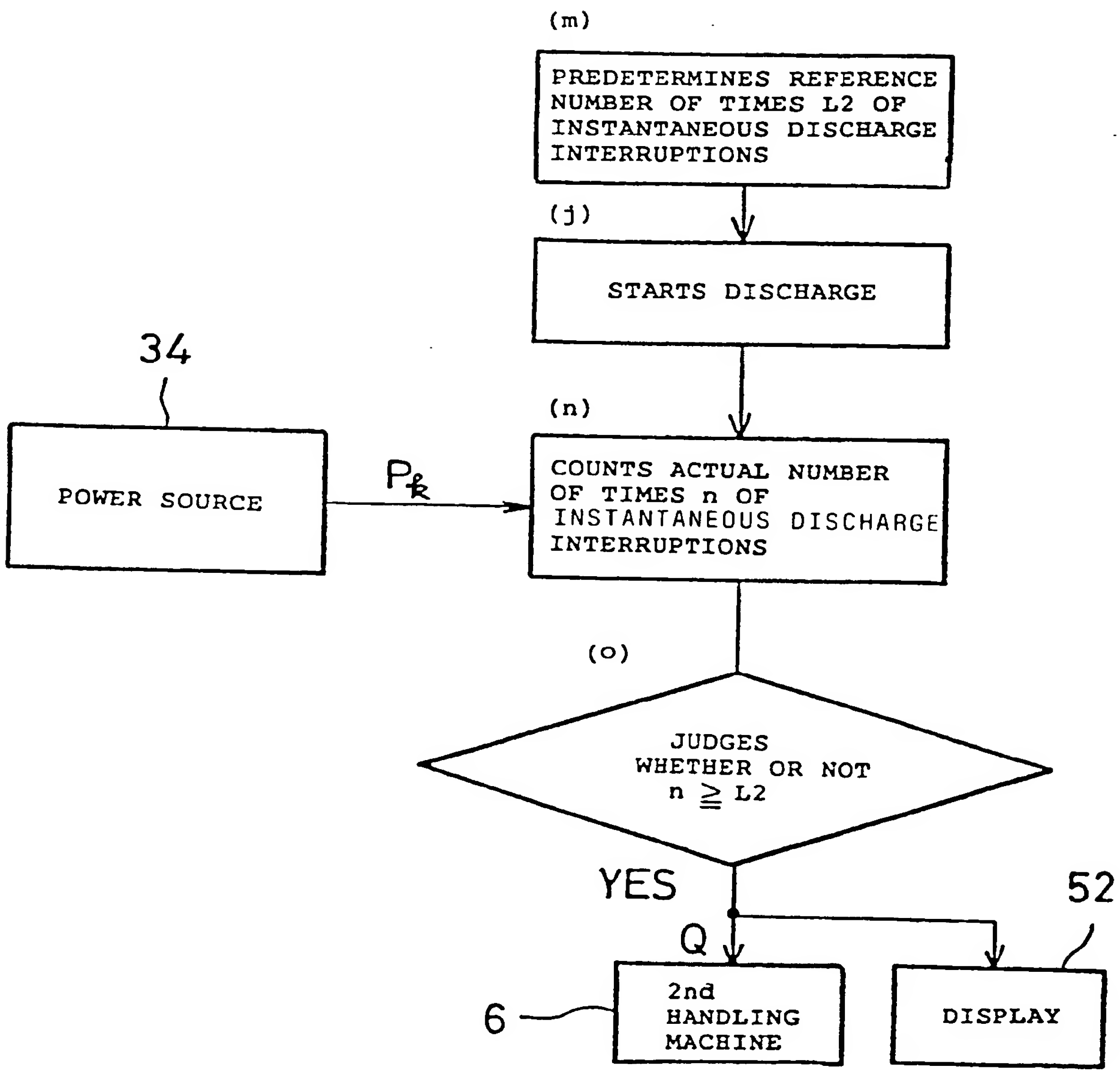
(m)
PREDETERMINES REFERENCE NUMBER OF TIMES L2 OF INSTANTANEOUS DISCHARGE INTERRUPTIONS
(j)
STARTS DISCHARGE
34
POWER SOURCE
$P_k$
(n)
COUNTS ACTUAL NUMBER OF TIMES n OF INSTANTANEOUS DISCHARGE INTERRUPTIONS
(o)
JUDGES WHETHER OR NOT $n \geqq L2$
YES
Q
52
6
2nd HANDLING MACHINE
DISPLAY

FIG. 11

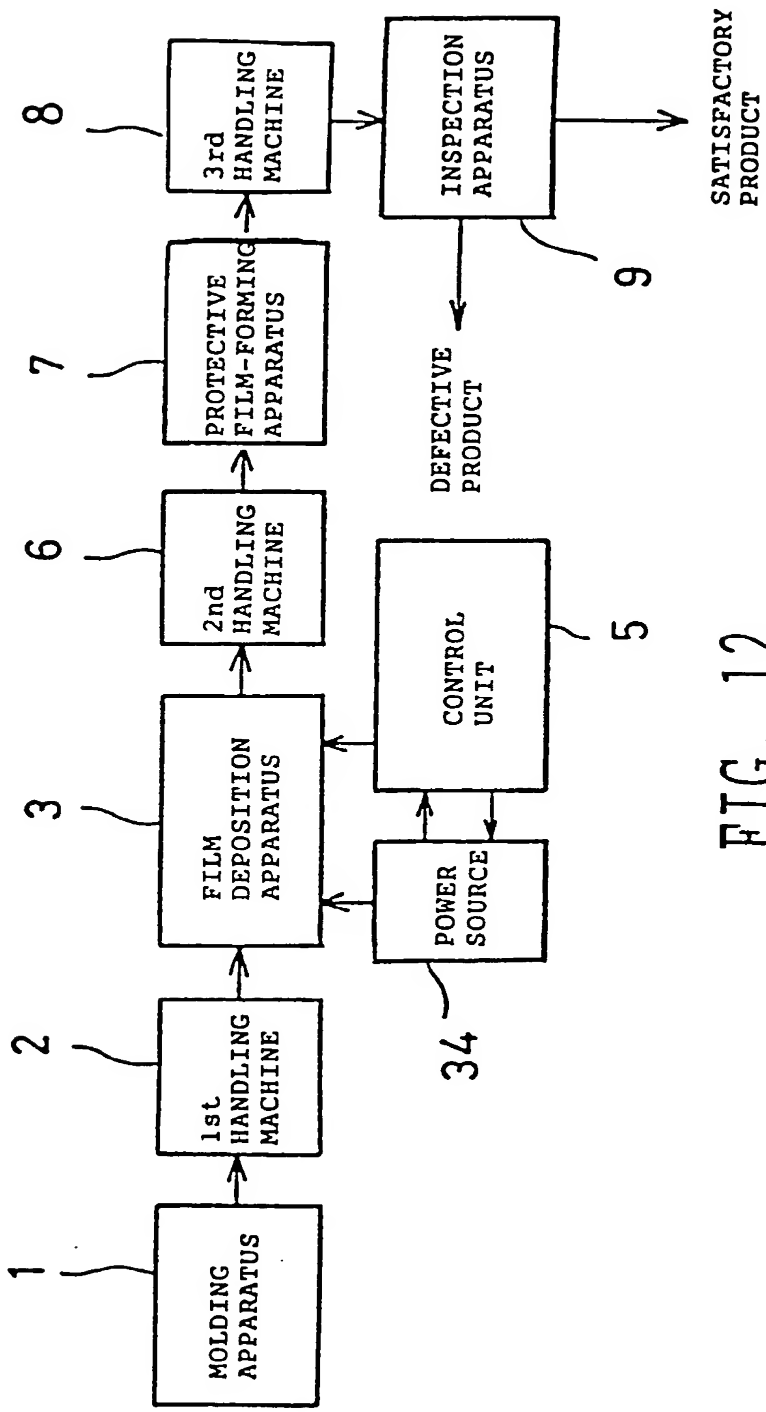


FIG. 12

PRIOR ART

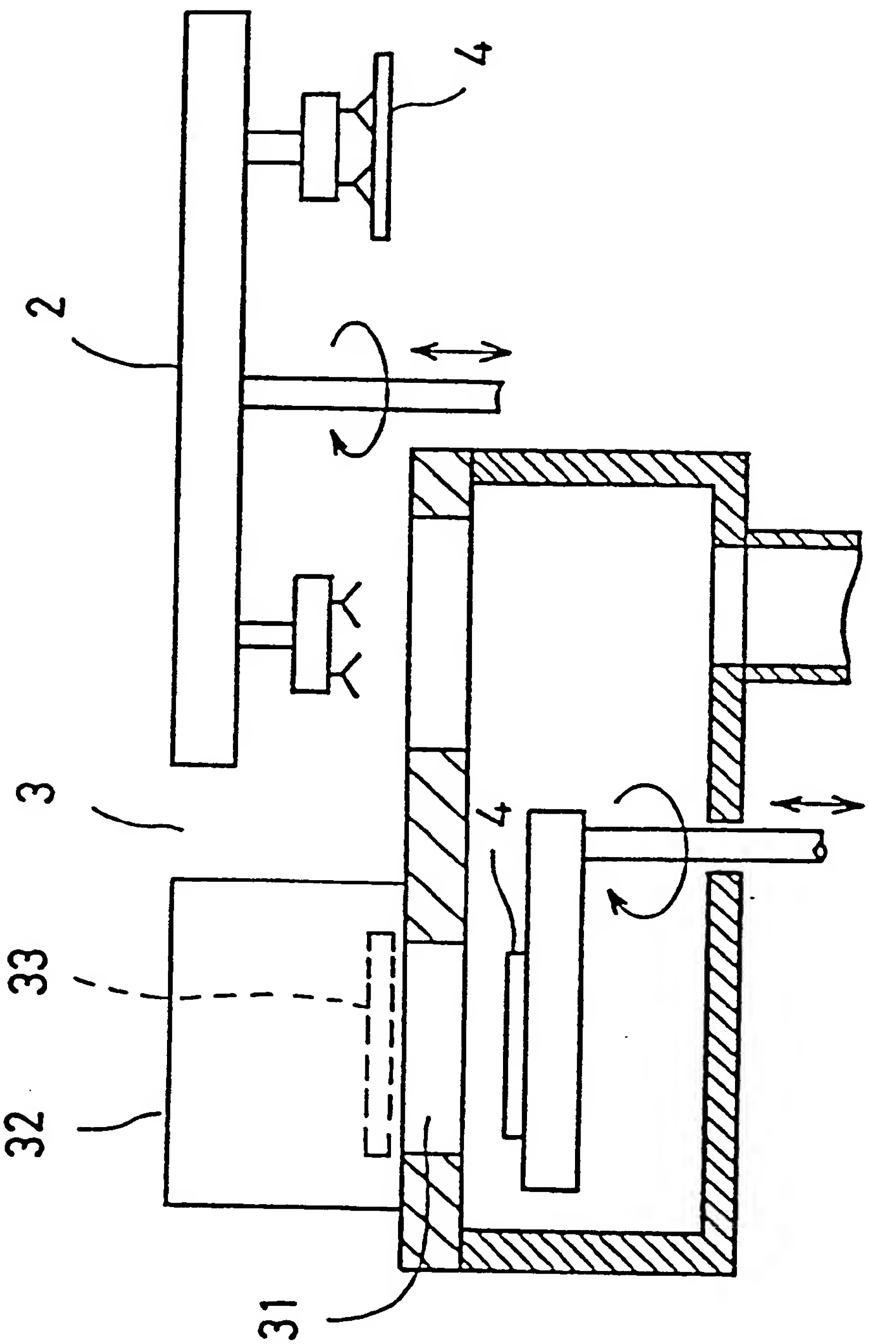


FIG. 13
PRIOR ART

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number

EP 91 40 2591

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5 ) |
|---|---|---|---|
| A | EP-A-0 393 957 (MATERIALS RESEARCH CORPORATION) * claims 2,9 * | 1-10 | C23C14/54 H01J37/32 C23C14/56 |
| A | SOLID STATE TECHNOLOGY vol. 32, no. 10, 1 October 1989, TULSA OK. USA. pages 125 - 126; 'SPUTTER COATER FOR SINGLE DISC PROCESSING' * page 126, column 3, line 31 - line 44 * | 1-10 | |
| A | US-A-4 500 408 (D.R.BOYS ET AL.) * figure 1 * | 1-10 | |
| A | US-A-4 847 792 (G.G.BARNA ET AL.) * column 4, line 50 - column 5, line 31 * * column 10, line 25 - line 32 * | 1-10 | |

TECHNICAL FIELDS SEARCHED (Int. Cl.5 )

C23C
H01J

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 19 MAY 1992 | EKHULT H.U. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

& : member of the same patent family, corresponding document

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